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CASE REPORT

CONSERVATIVE MANAGEMENT OF AN ISOLATED GRADE III LATERAL COLLATERAL LIGAMENT INJURY IN AN ADOLESCENT MULTI-SPORT ATHLETE: A CASE REPORT

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ABSTRACT

Study design: Case report

Background: Isolated, grade III lateral collateral ligament knee injuries are an uncommon traumatic injury with little guidance available in the literature for conservative management and prognosis for return to sport. The purpose of this case report is to describe the clinical decision-making in both differential diagnosis and physical therapy management of an isolated grade III lateral collateral ligament sprain in an adolescent multi-sport high school athlete.

Case Description: A 16 year-old male, high school, multi-sport athlete (cross country, wrestling, track and field) sustained a traumatic knee injury during a wrestling match when his involved lower extremity was forcefully externally rotated by his opponent. Initial clinical presentation revealed pain and increased laxity with varus stress testing of the left knee, which was subsequently identified via MRI as a complete lateral collateral ligament rupture (grade III). A conservative physical therapy program was developed targeting the active and neuromuscular subsystems, theorized to compensate for the lack of an intact lateral collateral ligament.

Outcomes: The subject attended 18 visits of physical therapy over a period of 12 weeks. His rehabilitation program focused on functional strengthening of the posterolateral corner, enhancement of neuromuscular control, and graded progression to sports specific drills. Return to play decisions were based on a combination of lower extremity functional performance measures, condition specific outcome measures and subjective performance on sports specific tasks. At discharge from physical therapy, he reported 0/10 pain, scored a 76/80 on the Lower Extremity Functional Scale, and was able to return to competitive track and field events.

Discussion: Few descriptions in the literature exist for the conservative management of isolated, grade III lateral collateral ligament injuries. A program of selective functional strengthening, proprioceptive training, and graded sport specific activities may allow these individuals to return to sport with conservative management.

Levels of Evidence: 4 (Single Case Report)

Key Words: Lateral collateral ligament, posterolateral corner, track and field

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BACKGROUND AND PURPOSE

Knee injuries constitute a major area of disability in sport. Epidemiological studies report the incidence of knee injuries comprising up to 39% of all related sport injuries,[1] reaching as high as 73.9% in some studies.[2] The most commonly injured structures include the anterior cruciate ligament (ACL), medial collateral ligament (MCL), and menisci.[1,3,4] Lateral ligament injuries of the knee are far less common overall, representing 1.1% of knee injuries.[1] Moreover, the lateral collateral ligament (LCL) is rarely injured in isolation; rather, concomitant cruciate, meniscal, and potentially peroneal nerve involvement are commonly seen.[5,6,7] This is observed both clinically and in cadaveric biomechanical models of injury.[8,9] When seen in combination, injures to the lateral side of the knee can also be a major source of failed cruciate ligament reconstructions when overlooked and not properly addressed during surgery.[10]

The LCL is a major passive stabilizer to the lateral aspect of the knee.[11,12] Considered a component of the posterolateral corner (PLC), the LCL is a primary static restraint to varus stress at the knee.[12] It is a secondary restraint to tibial external rotation, along with the popliteus tendon, popliteofibular ligament, and posterolateral capsule as more primary static restraints.[11,12] The LCL is most taut from 0˚-30˚ of knee flexion and is most suited to resist varus forces within this range, which corresponds to the accepted position of clinical tests to isolate the integrity of this ligament.[11,13] The LCL is also able to resist varus force through additional ranges of knee flexion, as well as contributing to stability to tibial internal rotation.[14] The LCL's role in restricting tibial external rotation is most optimum when the knee is in full extension, as this position places the greatest force upon this ligament.[10]

Because isolated LCL injuries are rare, detailed descriptions of their conservative management in the literature are limited, and are often considered more broadly with injuries to the PLC. The literature generally supports conservative management of grade I and II injuries, with grade III injuries often managed surgically,[10,15–19] although there is not a strict consensus.[9,20] The majority of reports of conservative management of LCL injuries do not provide sufficient detail to replicate from a rehabilitation perspective, aside from two examples, both of which are also in the context of injuries to the posterolateral corner.[19,21] The purpose of this case report is to describe the clinical decision-making in both differential diagnosis and physical therapy management of an isolated grade III lateral collateral ligament sprain in an adolescent multi-sport high school athlete.

CASE DESCRIPTION: HISTORY AND SYSTEMS REVIEW

The subject was a 16 year-old male high school athlete (1.60 m, 66 kg; BMI 25.8 m/kg^2), who participated in year-round competitive sports, including cross-country, wrestling and multiple track and field events (100 m, shot put and discus). His injury occurred during a wrestling match, when his planted, left lower leg was forcefully externally rotated from a standing position by his opponent in a take-down maneuver. He was unable to continue the match secondary to pain and limited ability to bear weight. Radiographs of the left knee taken in the emergency room were negative for fracture. He was given crutches to limit weight bearing and placed in a knee immobilizer. Two weeks later, he was evaluated by a pediatric orthopaedic physician who discontinued the knee brace and crutches, ordered an MRI, and referred the subject to physical therapy. The preliminary diagnosis by the physician was a left knee ACL and LCL tear, which was made prior to obtaining the MRI results.

The initial physical therapy evaluation was performed 3.5 weeks post injury. The subject reported no previous orthopedic injuries with an unremarkable past medical history. His chief complaints were localized lateral knee pain with weight bearing, activity limitations related to inability to ambulate with a normal gait pattern, and perceived knee instability most noted with stair descent. The subject had been able to participate fully in school with minimal limitations. He denied paresthesias into the lower extremity. The subject's goals were to return to sports as soon as possible, targeting the spring track season, which was to begin in two months. He rated his pain as a 5/10 at worst on the verbal numeric rating scale (VNRS) and scored a 49/80 on the Lower Extremity Functional Scale (LEFS).[22]

CLINICAL IMPRESSION #1

The subject's described mechanism of injury and reported symptoms of instability with ambulation and stairs suggested ligamentous involvement. Priorities for the examination included determining presence of intra-articular joint effusion, baseline range of motion and strength measures, analysis of function and gait, and special tests established for the ligamentous and intra-articular joint structures of the knee. From the subject's reported mechanism of injury, pain location and perceived instability of the affected knee, the examination was focused upon determining the integrity of the menisci, collateral and cruciate ligaments, and PLC.

EXAMINATION

The subject was tender with palpation to the lateral joint line and lateral femoral condyle. There was no appreciable knee effusion, with the subject exhibiting a negative ballottement test and score of zero on the stroke test.[23] Knee AROM was pain free and measured via standard goniometry to be equivalent bilaterally at 0˚-130º. Knee PROM was equivalent bilaterally as well, with 10 degrees hyperextension and a firm, painless end-feel into extension. He was unable to cross the left lower extremity over the right in sitting secondary to marked apprehension. Manual muscle testing to the left lower extremity revealed 4/5 strength of the knee flexors, knee extensors, and hip extensors. The subject demonstrated manual muscle testing of at least a 3/5 for the left hip abductor strength with the knee immobilized, but with complaints of lateral left knee pain and fear of movement into this plane of motion.

Analysis of the subject's gait revealed a number of compensations at the subject's ipsilateral hip that partially mitigated the demand for knee flexion in transitioning from terminal stance into initial swing. This included an increase in hip extension and posterior rotation of the pelvis into terminal stance and a concomitant mild ipsilateral hip hike into initial swing. As a result, the affected knee experienced a decreased knee flexion excursion during the transition from terminal stance through initial swing. Stair ascent was unaffected, though the subject was hesitant with weight acceptance on the affected leg with stair descent. The subject perceived discomfort at the lateral knee with terminal stance and was most apprehensive with weight acceptance in stair descent on the affected extremity.

Left knee ligamentous laxity was noted with varus stress test at both 30˚ and 0˚ of knee extension and graded as 2+ and 1+ respectively, though the subject exhibited negative anterior drawer and Lachman's tests. The posterior drawer test, posterior sag sign, and Dial test at both 30˚ and 90˚ were negative. The subject had a non-mechanical but painful McMurry's test for the lateral meniscus, but this was confounded by the presence of varus stress at the knee that occurs with this test. A summary of the pertinent examination findings can be found in Table 1.

CLINICAL IMPRESSION #2

The results of the initial physical therapy examination were consistent with findings of an isolated LCL injury. Clinical testing of the medial collateral ligament, cruciates and other structures of the posterolateral corner were negative, in addition to exhibiting a low likelihood of meniscal involvement.[24] Additionally, varus testing at 30˚ of knee flexion revealed a marked (+2) instability, with only a very slight (+1) instability at 0˚ of knee flexion, also supporting an isolated LCL injury.[25] Results from his MRI, two-days following his PT evaluation, confirmed a

Table 1. *Summary of Pertinent Exam Findings*

Examination Category	Clinical Findings
Gait	Decreased knee flexion at pre-swing, pain noted at terminal stance into pre-swing. Mild decreased stance time on left, compensatory ipsilateral hip hike into initial swing. No assistive device.
Strength	4/5 strength left knee flexors, knee extensors, hip extensors. At least 3/5 left hip abductors secondary to pain/apprehension to side-lying hip abduction. SLR without extensor lag
ROM	AROM Knee flexion 0-130 bilaterally. Extension PROM to 10° hyperextension bilaterally, pain free.
Special Tests	Stroke test 0. Negative ballottement. Positive varus stress test (1+ at 0° and 2+ at 30° of knee flexion) and positive Modified McMurry's for lateral meniscus. Negative anterior drawer, posterior drawer, Lachman's, posterior sag sign, Dial test at 30° and 90°.
Functional Performance	Inability to cross left leg to don shoes. Apprehension with weight acceptance with stair descent on left.

ROM = range of motion; AROM = active range of motion; PROM = passive range of motion complete proximal to mid-substance tear of the lateral collateral ligament along with bone marrow edema at the lateral femoral condyle, which may represent an avulsion mechanism of injury (Figure 1). The imaging report noted intact structures of the posterolateral corner (including the iliotibial band, biceps femoris and popliteus tendons), menisci and cruciate ligaments. This confirmed the clinical findings of isolated LCL laxity present with varus stress testing and apprehension to movements producing a varus stress at the knee (e.g., side lying hip abduction and crossing the affected leg to don shoes).

The subject's observed gait deviations were explainable by what is known about the biomechanical function of the LCL. The LCL contributes primarily to varus knee stability within the first 30° of knee flexion.[18] The subject's deviation seen during terminal stance into pre- and initial swing is consistent with the joint stability conferred by this ligament during these phases of the gait cycle, as the knee transitions from full extension and rapidly flexes into swing. Others have described gait deviations in this phase with injuries to the PLC involving the LCL.[18,21] The absence of a varus deformity or varus thrust during gait may have been due to the integrity of the remaining structures of the PLC.

INTERVENTION

The subject was seen for a total of 18 visits over a period of 12 weeks. The subject exhibited full left knee ROM, so the initial program design emphasized improving the strength and neuromuscular control of the active components of the PLC thought to compensate for the lack of the passive LCL restraint, while being mindful of protecting the knee from motions that would stress the joint from forces the LCL would normally restrain early in the rehab process.[19] The authors were initially cautious of exercises and activities that may generate varus and/or tibial external rotation stresses to the knee, particularly in light of the hesitancy seen with side-lying hip abduction and assuming the figure-four position. The authors adapted previous work describing conservative PLC injury management, as no rehabilitation protocols for isolated LCL injuries were found in the literature.[19]

Rehabilitation goals initially focused on normalizing gait, developing strength and neuromuscular control in the sagittal plane, proprioceptive activities, and progression to sports-specific training. Milestones were established for first gaining good control in the sagittal plane, with subsequent progression to frontal plane and finally rotary activities. The intervention plan was developed with the subject's goal of participating in

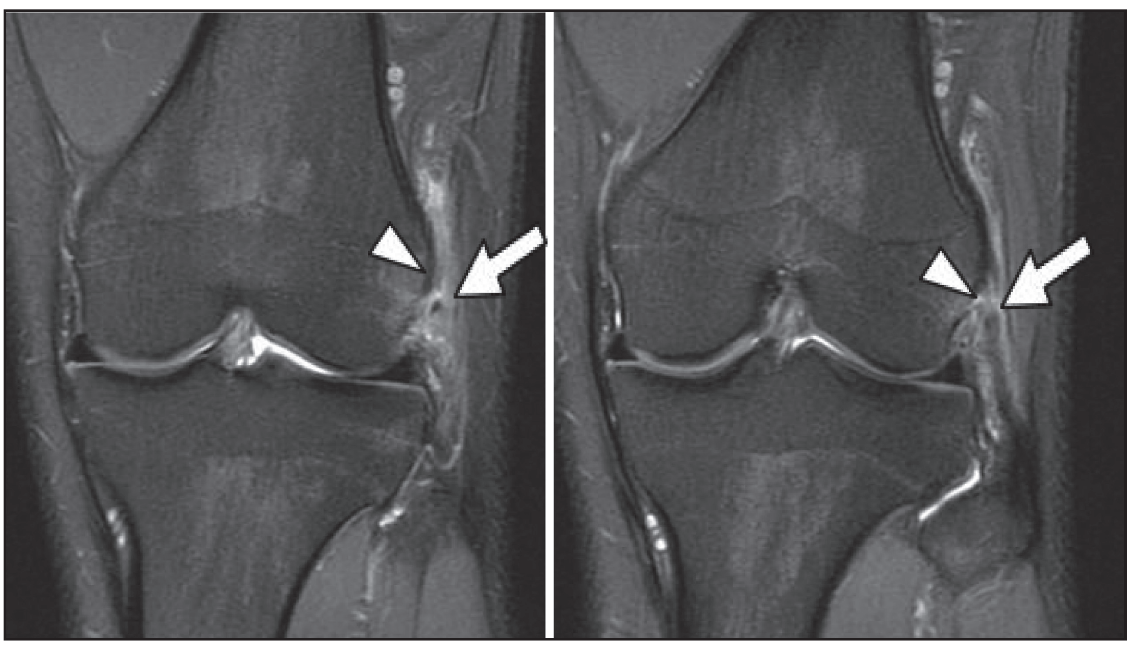

Figure 1. *Consecutive coronal fat suppressed proton density (PD) weighted images of the left knee demonstrate complete tear of the LCL proximally (arrow) associated with bone marrow edema (arrowhead) of the lateral femoral condyle at the femoral attachment of the LCL. Bone marrow edema may be due to avulsion injury from the proximal portion of the LCL.*

the spring track season for the 100m, shot put and discus events. Optimal conservative management would ideally allow the subject to first be able to participate in the 100m sprint, as this is primarily a sagittal plane activity. The shot put and discus involve a progressive demand for multi-planar stability, especially with the rotary component of the discus throw. The authors hypothesized return to these activities would come later in the rehabilitation process.

The rehabilitation program was divided into four distinct phases, correlating to what has been described in the literature (Table 2).[19] Based on the subject's evaluation findings (normalized knee extension ROM, knee flexion $>120^{\circ}$, performing a straight leg raise without a quadriceps lag, and absent knee effusion) he was deemed appropriate to begin in Phase II relative to those previously outlined.[19] He was initially seen two times per week, with tapering frequency to once per week as he progressed to sport practice and independence with his home exercise program. Table 2 presents each rehabilitation phase with selected exercise interventions, remaining activity and participation restrictions and accomplishment of milestones. Progression between phases was based on a combination of rehabilitation milestones, continued participation restrictions, and periodic clinical evaluation by the subject's orthopedic physician and physical therapist.

Phase II: Weeks 3-5 (Visits 1-6)

The primary goals of this phase were to normalize the subject's gait mechanics and ability to climb stairs to pre-injury status through a combination of gait training, therapeutic exercise, and neuromuscular reeducation. Gait training was accomplished on free over-ground using verbal feedback to promote increasing knee flexion into initial swing. Verbal cues were given for "let your back knee bend when you start to move it forward" and to discourage the compensatory motions at the hip. Cues were incorporated into bouts of approximately five minutes each over two of the initial PT sessions.

During this phase, therapeutic exercise targeted the strength of the quadriceps, hamstrings, hip extensors and hip external rotators. The authors were particularly interested in initiating exercises that would target musculature theorized to compensate for the

Table 2. *Rehabilitation phases for the conservative management of an isolated LCL tear*

	Selected Intervention	Milestones on Phase Completion	Precautions/Limitation
Phase II-Weeks 3- 5	Modalities (e.g., ice) as needed, knee ROM and mobilization techniques, lower extremity strengthening exercise	Painfree ADL's, no knee effusion, full knee ROM, 4+/5 strength to the involved lower extremity	Precautions with varus and tibial ER stres
	Double limb proprioception activities	Normalized gait and reciprocal stair negotiation	
	Bridge progression (Figure 2)		
	Static and dynamic squats, lateral resisted walk		
Phase III-Weeks 6-9	Continue previous phase interventions	Painfree ADL's, no knee effusion, full knee ROM, 5/5 strength to the involved lower extremity	Knee soreness rules for running /activity progression
	Running program	LEFS > 68/80	
	Agility ladder, sagittal to frontal plane progression	Timed 6m hop = 100%, Triple hop = 90%	
	Static unidirectional lunges, progression to dynamic and multi-directional	Completed running program	
	Double-limb chops		
	Weighted lateral walk with obstacle stepover		
	Bilateral/unilateral straight-leg deadlift		
Phase IV-Weeks 10-15	Lateral sprinting, progress to full effort	Painfree ADL's, no knee effusion, full knee ROM, 5/5 strength to the involved lower extremity	
	Mountain climbers	LEFS > 76/80	
	Single-limb chops	Timed 6m hop > 90%, Triple hop > 90%	
	Discus throw progression		
	Storks/Unilateral straight-leg deadlifts on angles		

Dosage of exercises were up to 3 sets of 10 to 15 repetitions each at 10 repetition maximum intensity, agility ladder at 30 sec to 1 minute bouts.

LCL = lateral collateral ligament; ROM = range of motion; ADL = activities of daily living; LEFS = Lower Extremity Functional Scale lack of an intact LCL, such as the lateral hamstrings. Exercises in this phase consisted of a combination of bridging activities (Figure 2). A bridging exercise progression was chosen to initiate strengthening of the hamstring complex (semimembranosus, semitendinosis and the long and short heads of the biceps femoris). Through inclusion of the bridge on a physioball, the authors were also able to incorporate a static, support phase (bridge with single limb support) and involve the popliteus with its role in tibial internal rotation in the early phase of knee flexion (bridge with knee flexion). Squats were progressed from supported (wall squats) to unsupported, and from stable to unstable surfaces as a means to introduce double limb proprioceptive activities. Stairs were addressed with focus on eccentric quad control and proper lower extremity alignment. This was initially approached cautiously early on secondary to pain with excessive tibial external rotation. Lateral stepping activities and static single limb balance/proprioception exercises were also incorporated.

Midway through this phase the subject reported a perceived return to normalized gait, no difficulty with stair descent, and was without marked pain during the school day. By the end of this phase, his pain was rated at 3/10 at worst on the NPRS. His sports medicine physician initiated a consultation with an orthopedic surgeon in order to determine if he was a surgical candidate. Surgery was deferred due to his progress with physical therapy, but would be considered in the future if recurring knee instability limited his function. He was subsequently cleared to run with return to sport decisions to be made based upon his performance in physical therapy.

Phase III: Weeks 6-9 (Visit 7-14)

This phase was characterized by strengthening in functional movement patterns designed to simulate sports specific tasks, a progressive running program and graded agility, neuromuscular control, and plyometric activities. The guiding treatment principle reflected the authors' hypothesis of first gaining adequate lower extremity sagittal plane control, prior to introducing activities requiring control in the frontal and transverse planes, as well as multi-planar activities. The authors also developed and utilized a subjective rating scale for perceived effort when introducing novel activities in order to help grade a gradual return to sport simulation. In order to grade the subject's perceived effort and relate to potential symptoms, the subject rated on a 100-point percentage scale (where 0% was no effort and 100% was full, maximum effort) his effort with an activity, in addition to reporting any perceived pain and instability

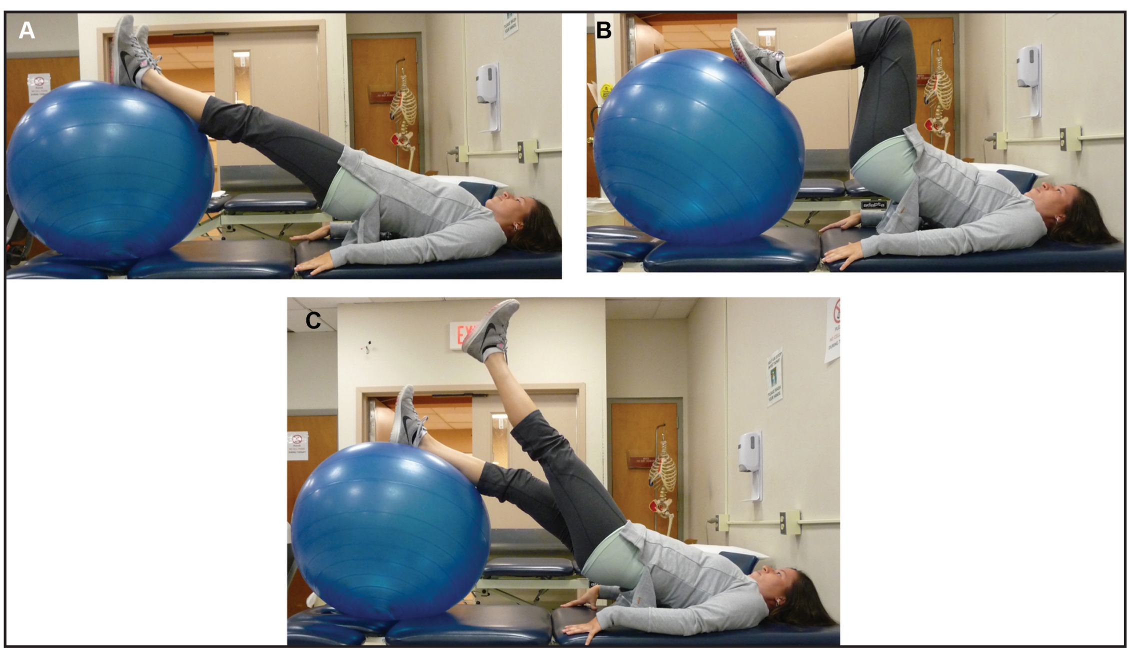

Figure 2. *Bridging exercise progression example (rehabilitation guidelines phase II). (A) Bilateral physioball bridges, (B) Bilateral physioball curls, and (C) Single leg physioball bridge kicks.*

at his knee. The subject was instructed to gradually increase effort, with any signs of instability or pain at higher efforts ceasing activity at that level. This was used in addition to the knee soreness rules to help guide treatment progression decisions.[26]

Exercises in this phase included lunges, straight-leg deadlifts, and step down exercises progressed in height with feedback given for proper form. The deadlifts were chosen to help focus on hamstring strengthening in a closed chain, and progressed from bilateral to unilateral support, with the goal of targeting the hamstrings as active support to the LCL deficient knee. Lateral walks were progressed with increasing resistance to challenge the frontal plane stability of the knee, as well as, increasing periods of single limb support by integrating stepping over obstacles. We also utilized a diagonal upper extremity flexion exercise (i.e., chops) for beginning to integrate the throwing motion of the shot put (Figure 3). This was also progressed from double limb to single limb support.

Both agility and plyometric activities were integrated during this phase as well. An agility ladder was used to begin more dynamic training, as well as progressing to bounding activities to mimic and train for more explosive movements required in sprinting. The subject was familiar with this activity as it was part of his usual training regimen in track practices. The subject was instructed to gradually increase effort, with any signs of instability or pain at higher efforts ceasing activity at that level.

During this phase, the subject began a return to running progression. Our criteria for running were maintaining the absence of knee effusion, pain-free jogging in the clinic without perceived apprehension and the performance of symptom-free bounding activity in the clinic. He was able to jog comfortably for short distances in the clinic with good mechanics. Walk-run intervals were used to gradually increase his running tolerance on the treadmill. Intervals were gradually increased from two minutes up to 10 minutes of total run time in the clinic. At the end of this phase, the subject was able to run continuously for 20 minutes, sprint short distances comfortably, and perform shot put simulations and bounding to full perceived effort. Functional lower extremity testing at the end of this phase on the timed 6m hop and triple hop were 100% and 90% of the uninvolved limb, repectfully.[27,28] Walk through of the

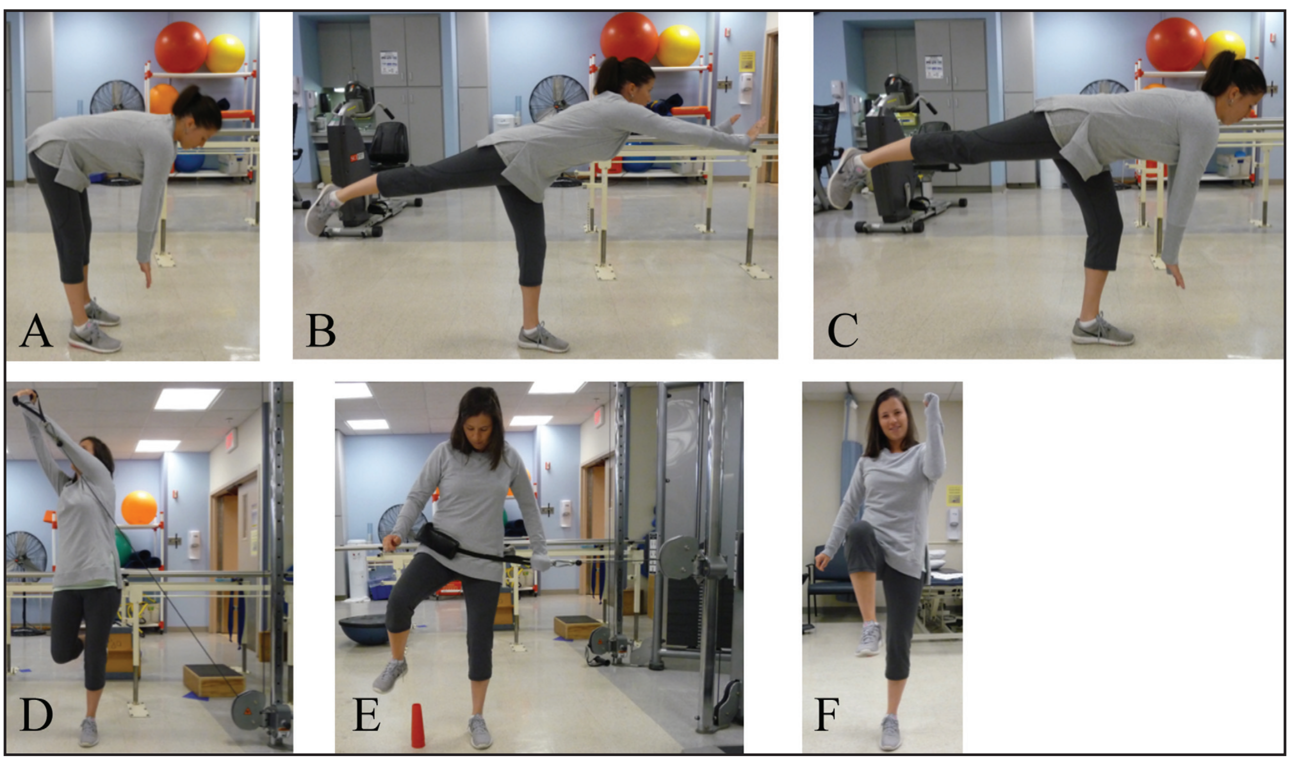

Figure 3. *Example exercises for rehabilitation phase III (functional strength). (A) Straight-leg deadlift, bilateral (B) Stork reach, (C) Straight-leg deadlift, unilateral (D) Chop, (E) Resisted lateral step-over, (F) Forward bounding.*

discus throw continued to elicit perceived instability on his affected lower extremity.

At that point, it was recommended that he be allowed to compete in both the shot put and sprints, based on his hop test performance and ability to demonstrate pain free performance in the clinic. Because he continued to experience symptoms with walk-through simulation of the discus throw, the subject was not cleared to participate in this event. His physician cleared him for participation in sprints and shot put, though discus participation was not allowed at this time. His home exercise program focused on double and single leg deadlifts, bounding, mountain climbers, and single leg chops, as well as running for conditioning two to three days per week.

Phase IV: Weeks 10-15 (Visit 15-18)

This final phase represented a gradual continued return to full sport activity, focusing on sports-specific drills for the discus and exercises directed at improving single limb multi-plane control. He began participating in sprinting and shot put at team practices and competing in weekly meets for these events during week 11. Exercises were progressed in this phase by increasing the speed of movement with the chop exercise and performing stork and single limb straight-leg deadlifts at angles deviating from pure sagittal plane motion to introduce a controlled rotary stress. Perturbation training with lunges and single limb proprioception/balance activities on a variety of surfaces were added in addition to integrating lateral sprinting for dynamic knee control.

Discus specific drills were completed by progressing from a walk-through speed increasing towards full speed using the subjective rating of perceived effort utilized for the bounding activity as described in Phase III. Verbal feedback for form was given to help with landing mechanics during the activity. Towards the end of this phase, discus throws were comfortable up to a reported 50% effort in the clinic with good observed form. At this point he was cleared to participate in discus in practice, with instructions to replicate gradual increase in effort with throws based on his perceived knee stability and continued absence of pain. Once he was able to throw at his rated 100% effort comfortably in practice, he then was allowed to participate in the discus event in competition. His last visit occurred following participating in all three events at the track championships at the end of the season.

OUTCOMES

The subject was able to return to full track competition and practice for the 100m and shot put during the beginning of Phase IV of his rehabilitation program, successfully competing in all three events at the end of Phase IV. Although functional measures including hop testing and LEFS scores met commonly accepted criteria for return to sport at the end of Phase III, he continued to experience apprehension with the discus throw. Additional treatment, with focus on functional strengthening and balance and proprioception with gradually increasing effort in discus throw simulations resulted in the ability to compete without perceived limitations.

DISCUSSION

Isolated, high-grade LCL injuries are rare in their occurrence making their rehabilitation challenging, from recognition of the salient clinical features of their presentation, intervention design, and prognosis. Two published examples of isolated LCL injuries have been reported in the literature.[20,29] Patel describes a radiographically confirmed, isolated grade III LCL rupture in a 34 year-old male, with the injury occurring during a yoga pose from placing his leg behind his head.[29] This subject also presented with no knee effusion and tested as a grade II laxity with varus stress testing. Interestingly, his mechanism of injury was similar to the movement of crossing one's legs to don shoes, an activity with which the subject of this case report was initially markedly apprehensive. Others have described this position as favoring palpable integrity of the LCL.[16] A second study retrospectively analyzed the management and outcomes of radiographically confirmed isolated Grade III LCL injuries in nine professional football players over a 10-year period. Interestingly, five of these players returned to competition within six weeks, with conservative management and bracing, whereas four of these were treated operatively and did not return to play until the following season.[20] Those managed surgically had a lower overall duration of remaining playing years in the National Football League.[20] Unfortunately, the conservative management strategy used in the NFL study was not described in enough detail to allow for reproduction. This does indicate, however, that in elite level athletes, return to play can be realistically achieved with bracing in the short-term, and that, conservative management allowed these individuals to continue to play subsequent seasons in the league. It is unclear as to what criteria were used to decide on surgical intervention in that subset of isolated Grade III LCL injuries.

This case report highlights a previously raised issue with the difference between a radiographic grading scale and that seen with attempting to grade ligamentous instability clinically with the LCL.[20,30] For lateral sided knee injuries, it has been shown that the clinical grading scales based upon results of special tests are not an accurate measure of instability.[31] For complete disruption of the LCL in particular, varus openings of 2.7mm are to be expected with varus stress leading these authors to argue that the clinical grading scale is an inaccurate measure of instability.[31] This has been previously supported clinically with the Bushnell study[20] and in the case report of a complete disruption in the subject during yoga,[29] when these individuals tested a grade II, with MRI showing a complete LCL disruption in isolation. This is consistent with the clinical presentation of the subject in this case report, which may be due to the partial redundancy of structures at the PLC that resist varus stress. Had the subject in this case report continued to exhibit symptoms of instability with activity and been unable to return to sport, he may have benefited for a referral for possible surgical intervention. Current recommendations for surgery would involve the use of an autogenous semitendonosis tendon graft for anatomic reconstruction.[30]

The subject's management strategy was based on a combination of interventions previously reported for the non-operative management of PLC injury, including functional strengthening of structures thought to compensate for the deficient ligament, and sports specific drills utilizing increasing subjective effort as a progression method. He began physical therapy after the acute phase of injury without needing to address basic impairments such as ROM or edema management, as would be required in Phase I in various protocols.[19] He was able to progress through the gait normalization phase with verbal feedback and the use of simple non-weight bearing and weight bearing activities focusing on quadriceps and hamstring strength and developing proprioception. The subject was initially protected from activities involving varus and tibial external rotation stresses, based on his apprehension with these activities initially and from what is known about the biomechanical function of the LCL.

Later phases of the subject's rehabilitation relied on functional strengthening of structures of the PLC, continued balance and proprioception, and sports-specific drills. A graded introduction of activities producing varus and rotary stress were also included in this phase. The authors initially hypothesized a timeline of return to sport of first 100m sprints, followed by shot put and finally the discus. This was based on the requirement of increasing stability demands of these activities at the knee, from more pure sagittal plane (sprinting) to progressive increases in multiplanar stability demands as seen with the shot put and discus. The subject had returned to both sprinting and shot put early in Phase IV, though continued with perceived apprehension with the discus. The discus in particular involves over 540 degrees of full body rotation, with the in-circle throwing motion divided into five distinct phases.[32] Proper throwing technique involves periods of both single-limb and double-limb phases, involving rapid pivoting on the lower extremities.[33] For a right-handed thrower, the left leg is subjected to both a rotary and varus stress at high-speeds. This certainly involves a demanding degree of rotary stability at the knee, which the subject was last to fully develop adequately to allow for participation without symptoms. His ability to participate in these events, including the discus event, is indicative of the redundancy of the active, passive and neuromuscular control subsystems of the knee that can allow one to function without an intact LCL.

The authors do acknowledge several limitations to this study, which limit the generalizability of the study's outcomes. The very nature of a single case report limits the applicability to a larger population. A longer-term follow-up with the subject after discharge could not be completed, therefore it cannot be determined if the success of this program translated to continued functional success beyond this course of physical therapy. Aside from a longer-term outcome, it is also not known if the lack of an intact LCL would predispose this individual to either an acute lower extremity injury via the increased stress on the cruciate ligaments seen in LCL deficiency, or potentially to further chronic injury of the affected knee (e.g., medial compartment degeneration), which has been demonstrated in animal models.[10] These caveats need to be considered when considering the outcomes presented in this case report.

CONCLUSION

This case report describes the identification of and conservative management of an isolated, high-grade LCL injury in a multi-sport high school athlete. By taking a functional strengthening and sports-specific drill progression approach, the subject was able to successfully return to competitive sports. This case report provides guidelines for the successful conservative management of and timeline for recovery from these injuries.

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